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Dr Baker

AN

INAUGURAL ESSAY

ON

RESPIRATION,

SUBMITTED TO THE EXAMINATION OF

The Honourable ROBERT SMITH, *Provost*,

And of the Regents of the University of Maryland,

FOR THE DEGREE OF DOCTOR OF PHYSICK.

BY SAMUEL MARTIN,

OF VIRGINIA.

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"Spoil'd of its balm and sprightly zest, the blood
Grows vapid phlegm;" ARMSTRONG.

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MAY, 1813.

TO JAMES COCKE, M. D.

Professor of Anatomy in the University of Maryland.

The object of this dedication, dear sir, is not to insure your patronage for this production, but to evince my high estimation of those superior talents with which you are endowed. And, whilst I render this small tribute to your talents, and distinguished merit, permit me, sir, to express the impulse of my heart, in cherishing a grateful recollection of those numberless favours conferred by yourself; and, the peculiar obligation I owe to your amiable consort, whose dignified deportment and uniform kindness ever since I had the honour of being known to her, demand my highest compliment, and warmest sense of gratitude.

Under these impressions, I claim the privilege of dedicating to you, this essay. With the best wishes for your health and happiness, and for a continuance of your usefulness,

I remain,

Your much obliged,

S. MARTIN.

April, 1813.

TO DRS. SELDEN & WHITEHEAD,

Of Norfolk, Virginia.

The personal knowledge which I have of your zeal and superiority in medical science, and your gentlemanly deportment, together with the claim which you have on my gratitude, is a sufficient apology (if any be necessary) for affixing your names to this my inaugural dissertation.

Accept gentlemen, my most earnest wish for your health and prosperity.

Your friend and

Former pupil,

S. MARTIN

April, 1813.

TO DR. ZACHARIAH MARTIN,

Of Dinwiddie, Virginia.

DEAR SIR,

THE honors conferable by a University are considered a just reward to the student for the acquirements made in his profession. These honors, sir, are now about to be conferred upon me, and as I am greatly indebted to your paternal care and kind instruction for the progress which I have made in the science of medicine, I cannot do otherwise than obey the dictates of my heart in availing myself of this opportunity, to offer you my most sincere acknowledgements.

With the warmest wishes for your health and longevity, I am,

Your obliged friend

and relative,

S. MARTIN.

April, 1813.

INTRODUCTION.

OF the various segments which constitute the extensive circle of medical science, that which forms the base of the physiological department, presents the most alluring prospect of instruction and amusement. I consider therefore, subjects of this kind, particularly entitled to our attention.

Amidst the great variety, constituting physiology, I have experienced no small degree of difficulty and hesitation in selecting. But, after a mature deliberation, I have resolved to institute a brief enquiry into the nature and objects of respiration.

Various opinions have been advanced on the subject of respiration, I have therefore, in the course of this essay, necessarily been led to notice some of the principal theories, and, I trust that in so doing, it will be found that I have observed due respect to all.

My object here, is not to advance a doctrine entirely new, nor will that be expected from a man entering on the threshold of science—the time alloted by the laws of the University, for the production of inaugural dissertations, would, moreover preclude the hope of success. My only aim is to make a fair and honorable investigation of the matter, and expose to view the truth of one and the fallacy of others.

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THESIS.

RESPIRATION is that function by which air is received into the lungs and afterwards thrown out. The apparatus destined to effectuate this object I deem it unnecessary to describe minutely. The diaphragm, intercostal and abdominal muscles are the chief active parts engaged in expanding and contracting the cavity of the thorax. The lungs are two large, light, and spongy bodies, appended to the tube called trachea, the divisions of which separate into smaller branches which terminate in cells for the reception of the air. These cells are lined by a membrane of exquisite delicacy, on which are distributed very largely the slender branches of the pulmonary artery, which after having been spread over a very extensive surface, terminate in the minute commencements of veins, which uniting together form the four pulmonary veins by which the blood is returned from the lungs to the left auricle of the heart. The vascular network of which I have just spoken has been called the *Rete mirabile* of Malpighi. The air cells and ramifications of the bronchia, the branches of the pulmonary artery, and the pulmonary veins, together with a species of loose cellular texture which connects and supports all those parts, and which is called interlobular substance, constitute the mass of the lungs. Of the broncheal arteries and veins, as well as of the nerves and absorbents of the lungs, I hold it unnecessary to say any thing.

So highly interesting is the process of respiration, that if the limits of a Thesis would admit of so extensive a range being taken, I should premise the essay which I contemplate writing on respiration as it is performed in man and other members of the class mammalea by a suscinct view of the process of respiration as it is performed in inferior orders of ani-

mals, as in birds, fishes, &c. and even of that imperfect species of respiration which is performed by plants.

Accident probably suggested to the first reasoning creature that ever inhabited the earth, that breathing was indispensable to his existence.

In the oldest book extant we find the "breath of life" spoken of. Many of the philosophers of antiquity had confused ideas of the importance of air, which, they considered to be the principle of all bodies. Empedocles, supposed respiration to be accomplished chiefly by the nose, and that it was caused by the vacuum which was frequently formed by the motion of the blood in a part of the veins. Innumerable conjectures, or theories, if they can be entitled to that name, were made by the antients with regard to the nature and use of the air taken in in respiration. These theories were, from the state of science at the time when they were made, necessarily crude and incorrect; and are in no other view interesting, than as they shew us how vigorous minds cope with insuperable difficulties. Of the great number of opinions which were entertained on this subject, it may not be inexpedient to notice a few of those which were held by some of the most conspicuous characters of different ages.

Hippocrates believed air to be a species of aliment that was necessary to the animal system. Galen advocated the idea that respiration was chiefly intended to temper the blood and carry off the fuliginous vapours with which it is loaded, by the vital fire constantly kept up in the heart. Pliny seems to have understood that the air was highly important, as he calls it the "vital spirit"—according to the Roman orator Cicero, "the heart imbibed the spirit from the air."

In modern times there have not been wanting advocates of the doctrine, that the air in the lungs acted as a refrigeratory in cooling and condensing the blood, heated as it was presumed by the vital fire in the heart. A writer by the name of Stevenson, suggested the idea that the air which had circulated in the blood and which had heated it too much was exhaled by the lungs. That ingenious philosopher, Boyle, supposed that the air itself was not admitted to the blood, but that that fluid derived from it some active spirituous and ethereal particles; that this vital spirit passes from the lungs to the heart and arteries, and at length becomes the animal spirits. Some others who denied that the animal spirits were obtained from the air, allow that some other vital principle is supplied by it to the blood. Although the conjectures which I have noticed were some of them ingenious; their relation to the truth, according to the present view of philosophers on that subject, was very remote. The celebrated Mayow, however, trod on

the confines of that important discovery which has shed such lustre on the chemistry of more modern times. He knew the use of air in combustion and respiration, and had marked the diminution and absorption of it in those processes. He asserted that a part of the atmosphere, which he called the vital part, was absorbed by the blood, and that the warmth of that fluid was ascribable to that absorption : nor was he ignorant of the fact that the high red or arterial colour of the blood, is caused by what he called the vital part of the air. Had he known the composition of the atmosphere, or been able to separate its component parts, the philosophical world would probably at a much earlier period have been put in possession of the now received theories of combustion, acidification and respiration.

It was conjectured by some philosophers that one of the chief uses of the lungs was to attenuate and to mix the different constituent parts of the blood. A celebrated medical philosopher of Edinburg was of opinion that something of a vital and stimulating nature was communicated by the air to the blood; and Sir Isaac Newton entertained the idea that an acid vapour passed from the air into the blood, and that it was necessary to keep up the action of the heart. Cigna advanced a doctrine different from any thing that had been previously entertained, which is that the air acted not chemically but mechanically, and that it was taken into the blood for the purpose of counteracting the pressure of the atmosphere.

Long had the ablest philosophers continued to study the subject of respiration, and to offer new and vague theories on it, and must have continued in darknes as to its nature, if the composition of the atmosphere had not been ascertained. The discovery of oxygen was made about the same time by Priestly, by Scheele, and by Lavoisier, from each of whom it received a different name. Priestly the able advocate and last remaining pillar of the phlogistic theory called the gas which he discovered, (by accident when in pursuit of some other object,) dephlogisticated air : by Scheele, the same air was called empyerial air, and Lavoisier gave to it the name of vital air. From its having subsequently been found to be the principle of acidification it was called oxygen, and that name was very universally received, and is now generally retained; although Sir Humphry Davy, for reasons which it is unnecessary to mention in this place, has substituted the name of phos-oxygen for oxygen.

However ably Dr. Priestly reasoned, however valuable we admit his discoveries to be, and however important many of his experiments, his attachment was so unalterable to the doctrine of phlogiston, and he on so many occasions introduces it into his explanations, that it does not appear to me to be possible

to profit much by studying the theory of respiration which he has advocated. Bergman, Scheele, Fontana, Landriani and other chemists and philosophers differed from Priestly, and amongst themselves, with respect to phlogiston, but as they were all believers in the existence and extensive agency of that principle, now, I believe, universally admitted to be imaginary, their doctrines on the subject of respiration are scarcely worth investigation.

To those chemists and philosophers only, who, with minds disencumbered of the doctrine of phlogiston, proceeded to the examination of the process of respiration, can we reasonably look for interesting information on that subject. Lavoisier having ascertained that oxygen could be entirely converted into carbonic acid gas by the addition of pulverized charcoal, and knowing that carbonic acid is emitted from the lungs, supposed that in respiration such combination was made, and that a part of the oxygen taken into the lungs meeting with the excreted carbon, formed carbonic acid gas. Another part meeting with hydrogen he supposed to form water, a third portion being returned unaltered.

By an experiment of Doctor Goodwin, it appears that of 100 parts of common air inspired, there are 80 parts of nitrogen, 18 of oxygen, and 2 of carbonic acid gas: the air when expired has been found to be changed as to the proportions of its parts—the nitrogen is returned unaltered and undiminished, constituting 80 parts; the oxygen is found to be diminished to 5 parts, and the carbonic acid gas to be increased to the extent of 13 parts, which being added together, make 98 parts, two being lost, which may perhaps have contributed to form water, which would be likely to elude the observation of the experimenter. The theories of both Lavosier and Goodwin appear to me to be incorrect, as both these authors entertain the idea that the carbonic acid is formed in the lungs.

Various opinions have been entertained as to the colour of the blood. I shall not even enumerate or name the doctrines of the antients on this subject, nor do I think it necessary to attempt to refute the opinions of those who consider the imaginary principle of phlogiston to have any agency in the business.

Lavoisier and Crawford, concluded that the dark colour of venous blood is owing to the circumstance of that fluid uniting with hydrogen in the course of the circulation, and that as the blood passes through the lungs and has an opportunity to throw off the superabundant hydrogen, that it assumes its arterial colour. Whence is the hydrogen derived? From all the experiments which were made by Dr. Goodwin, with a view to ascertain the cause of the vermillion red, or arterial

colour of the blood, he has come to these conclusions, that, a quantity of oxygen is separated from the atmospheric air in the lungs, and that this oxygen exerts a chemical action upon the pulmonary blood, in consequence of which it acquires a florid colour. There is something specious in this conclusion of Dr. Goodwin, and it is probably correct, but when it is examined it will be found to be announced in such general terms, that we cannot understand what particular idea he means to convey.

From a series of ingenious and interesting experiments, Girtanner was induced to make the following conclusions, 1st. That the change of colour in the blood during circulation is not owing to its combination with hydrogen. 2nd. That the vermillion colour of arterial blood arises from oxygen with which the blood combines during its circulation through the lungs. 3rd. That the deep colour of the venous blood is owing to the carbon it contains. Girtanner supposes carbonic acid to be formed in the lungs.

On these conclusions, I will take occasion to remark that the first is probably true, the second would I think be more correct, if the oxygen had been said to be mixed with the blood—the third I hold to be altogether incorrect, as, it has been satisfactorily shown by the Professor of Anatomy in the University of Maryland, that the blood does not contain one particle more of carbon when it returns to the right auricle of the heart, than it does when it passes by the pulmonary veins to the heart, or when it is thrown from the left ventricle into the aortic system.

Hassenfratz, concludes that the arterial or vermillion colour of the blood proceeds from the solution of oxygen gas—and that the venous or modena colour arises from the oxygen having combined chemically with the hydrogen and carbon.

The last conjecture which has been made on the cause of the colour of arterial blood, is that offered by Mr. Davy, who attributes its vermillion colour to light and oxygen, or to what he has been pleased to call phos-oxygen, being absorbed. The dark colour of the venous blood he ascribes to a deficiency of phos-oxygen or to a superabundance of carbon. Numerous experiments shew that arterial blood becomes of a dark colour without the addition of carbon, as in those instances in which arterial blood has been received into vials, which have been afterwards carefully sealed up.

The intimate connexion of animal heat with respiration, appears to require that I should give some account of the ideas which have been at different periods entertained on that subject. So thorougly destitute of foundation in true philosophy, are the doctrines of the antients and of some modern writers

on this subject, that I should consider it a waste of time, to give an account of the authors of such notions; as that heat was immortal or innate, that it is the result of effervescence in the stomach and bowels, or of the mixture of acids and alkalies—of fermentation of friction, either of the blood against the blood vessels, or of the particles of the blood against each other; nor does the idea of heat, being produced by the union of phosphorus and air which are brought into contact with each other by means of the circulation, appear to be more entitled to attention.

The theory of Dr. Black, the great father of modern chemistry, shews strong evidences of its author not having freed himself from Sthalean droctrines, when it was formed.

The theory of the ingenious Dr. Adair Crawford, on animal heat, was so universally received, that notwithstanding his unacquaintance with the nature of oxygen, and his strong bias to the doctrine of phlogiston, I consider it necessary to give some particular attention to it, especially as it is suspected by some persons to be the father of the theory of the able professor of chemistry in this university.

I should be pleased if the limits of a Thesis, would admit of my giving a place to the definitions, estimates and propositions of this very respectable and ingenious author, on the subject of animal heat. But I find it necessary, to restrict myself to giving an insertion only to his general conclusions, as to the source and production of animal heat. It appears from what Dr. Crawford says, " that animal heat depends upon a process resembling a chemical elective attraction. The pure air is received into the lungs, containing a quantity of elementary fire; the blood is returned from the extremities impregnated with the inflammable principle; the attraction of pure air to that principle, is greater than that of the blood. This principle, will therefore leave the blood to combine with the air; by this combination, the air is obliged to deposit a part of its elementary fire, and as the capacity of the blood is at the same moment increased, it will instantly absorb that portion of the heat detached from the air. The arterial blood in its passage through the capillary vessels, is again impregnated with the inflammable principle, hence its capacity for heat is diminished, it will therefore gradually give out the heat it received in the lungs, and diffuse it over the whole system. Thus in respiration the blood is continually discharging the inflammable principle and absorbing heat, and in its circulation continually imbibing this principle and emitting heat."

This appears to be the substance of Dr. Crawford's theory of animal heat—except, indeed, that when this theory does

not answer, as in cold blooded animals which have no lungs—he presumes the heat to be supplied by their aliment.

Independently of the positive grounds which might be taken against the existence of what the learned author calls the inflammable principle, which term appears to me, to be synonymous with the word phlogiston, it may be objected to this theory, that there is no evidence of matter of any kind being imparted to the blood, in the whole course of the circulation, from the time it leaves the lungs until it has gone through the entire aortic system and has returned into the great veins, of the dark venous colour. I cannot imagine the channels by which the inflammable principle gets access to the blood—again, admit as contended by this gentleman, that the inflammable principle leaves the blood to combine with the air, and that by this combination, the air is obliged to deposit a part of its elementary fire. Let us enquire what is the force of this elementary fire. Dr. Crawford, having established the fact, as he says, "that pure air at the common temperature of the atmosphere, contains 1550 degrees of heat, if a certain quantity of pure air, not in contact with any body, that would immediately carry off the heat, should suddenly be converted into fixed air and aqueous vapour, the heat contained in the former would raise the latter 1550 degrees, multiplied by three or 4650 degrees; and the temperature of red hot iron being 1050, it follows, that the quantity of heat yeilded by pure air, when converted into fixed air and aqueous vapour, is such (if it were not dissipated) as would raise the air and vapour so changed to more than four times the excess of the heat of red hot iron, above the common temperature of the atmosphere. If therefore, the absolute heat which is disengaged from the air in respiration, were not absorbed by the blood, a very great degree of sensible heat would be produced in the lungs."

Admitting the blood to have its capacity for containing heat thus enlarged, by parting with its inflammable principle; the change in the air must take place in the air cells, and the first impression of this horrible heat, must be made on the fine membrane lining those cells, and on the delicate vessels expanded on it, and forming the *rete mirabile* of Malpighi—could they bear such consuming heat, not only occasionlly, but at every act of respiration? Dr. Crawford supposes the matter of heat, disengaged during respiration and combustion, to be in a free state in the pure air, and that it is only disengaged from the pure air losing a great part of its specific heat by combination. The opinion entertained on this subject, by chemists generally, is, that the heat disengaged during these two processes, is combined with the pure air, and that this gas

owes its æriform state to the expansive force of this combined heat.

Dela Grange, adverting to the absurdity of supposing the heat, which was supplied to the whole system, being envolved in the lungs, and thus distributed throughout every part of the system, very rationally objected, that those organs could not sustain a heat so inordinate as would be necessary to effect such an object; and moreover, in that case, the blood would be cooler in a direct ratio, to the time of absence or distance from the lungs, which is certainly not a fact. He concluded, therefore, that the blood, in passing through the lungs, dissolves the oxygen of the inspired air; that this dissolved oxygen quits, by degrees, its state of solution, to combine partially with the carbon and hydrogen of the blood, forming the water and carbonic acid, which are extricated from it as soon as the venous blood goes from the heart in order to enter the lungs. Hassenfratz concurs in the doctrine of Dela Grange, as to the manner in which oxygen, after being received into the blood, is disposed of, and carbonic acid and water are formed and exhaled in expiration.

Gren explains the matter very differently; he insists, that all the water exhaled in expiration, is of new formation, and that oxygen is only absorbed for the formation of water and carbonic acid gas; and that there remains none of it to combine with the blood; moreover, he asserts, that the change of venous to arterial blood in the lungs, does not depend on the absorption of oxygen, but on the separation of carbon and hydrogen.

To this doctrine, it may be simply remarked, that arterial blood, in a vial entirely filled with it and accurately sealed, assumes, after a certain time, the venous colour, and possesses still the capacity to have the vermillion red reproduced by the agency of oxygen—also oxygen introduced into the veins of a dog, has suddenly destroyed the life of the animal, when on examination, the blood in the right auricle was of a lively red colour; in neither of these cases, is there a possibility of the carbon and hydrogen being thrown off.

Another theory remains to be considered, which is, that of the celebrated professor Davy. The rank which Mr. Davy holds in the learned world, a life devoted to philosophical and chemical researches, and a conviction of my not having had an opportunity to acquire more than an extremely superficial acquaintance, with the experiments and trains of reasoning on which he has founded his doctrines, relative to respiration, cause me to tremble, when I feel myself called upon to notice his doctrines, and to object to part of his explanations.

I cannot consent to part with the droctrine of Caloric, which has been so long received, without more conclusive evidences, than I have seen in favour of Mr. Davy's opinion; that what has been designated heat, is merely "a vibration of the corpuscles of bodies tending to separate them, and hence to be called *repulsive motion.*"

One of the objections made by Mr. Davy, is, that oxygen is never decomposed by carbon, at a temperature so low as 98 degrees, and is never decomposed without combustion. He admits, that phos-oxygen combines with the blood in the lungs, and that carbonic acid and water are both liberated from the lungs, during this process, either by the increase of temperature, or from the superior affinity of phos-oxygen for the venous blood.

The grounds taken by Mr. Davy, are entirely new, and the strength of the reasonings and authority of the experiments which may be brought in support of them, are so far from being fully ascertained, that it is a thing of some difficulty to decide on the course that should be taken on that subject. I will, therefore, simply make the inquiry, whence the oxygen is derived that enters into the composition of the water and carbonic acid gas, admitted by that gentleman to be liberated from the lungs? and also in what part of the body a temperature is found higher than 98 degrees, which, he says, is lower than the lowest at which oxygen gas is decomposed by carbon? Is it not possible, that the exquisite state of division, in which carbon is found in the blood, may favour such decomposition at a lower point than that at which it will take place in the powder of carbon, however finely levigated?

Having given a rapid review of the different theories of respiration which appear to me most worthy of attention, I shall close this essay with an account of the theory which I have been induced to embrace.

The object of respiration is, unquestionably, to expose the blood to the influence of the atmospheric air, for the complete accomplishment of which the whole pulmonary system appears to have been expressly constructed and arranged.

When the chest is acted on by the muscles, the cavity of the thorax is enlarged and the lungs being passive in their nature, are inflated by the rushing in of the air which takes place conformably to a known law of the atmosphere.

Physioligists have puzzled themselves very much with a view to ascertain the cause of the first inspiration made by the newly born infant. By some of them it has been supposed that the air rushes in to fill a vacuum in the thorax—there can be no vacuum there, until the chest is expanded. Others have attributed the first act of inspiration to the fatigue to which the

infant has been subjected, in the course of parturition. Brute animals, at full time of gestation, have been opened, and the fœtuses lying tranquilly and undisturbedly, have been exposed to the air They have been found very soon to inhale the air, and to have the process of respiration established.

Various other conjectures have been made on this subject, but none of them appear to me to be at all satisfactory except one which has been offered by professor Cocke. Having noticed the uniform occurrence of the act of inspiration in newly born children, and perceiving no change of circumstances which should produce that effect except that the supply of oxygenated blood must have been diminished by the contraction of the vessels of the uterus, he concluded that the feeling of a deficiency of oxygen was the cause of the effort to inspire being made. When it is recollected, says the learned professor, that in several cases irritation in one part causes violent and involuntary actions to be instituted in other parts, for the relief of the offended parts, an irritation for instance on the snyderian membrane causes the muscles of respiration to be thrown into incontrolable operation in the act of sneezing: again, an irritation on the glottis or membrane lining the trachea, causes the same set of muscles to be sympathetically affected, and coughing is produced to afford relief from the unpleasant sensation; it will not be deemed unreasonable to conclude, that a similar sympathy or association may cause the muscles which expand the chest to act, to afford relief from the painful sensation which arises from a deficiency of oxygen in the system. To the same cause he attributes the repetition of the act of inspiration through life. The act becomes habitual and it is performed so frequently that we do not attend to the sensation which admonishes us to inspire ; if, however from accident or design we are prevented for only two minutes from inhaling air, the sensation which is thus produced is exceedingly distressing, and the desire for air is excessively vehement.—That we have occasion for air as often as it is ordinarily inhaled is shewn by the fact, that if from grief or close attention, we breath rather more slowly than usual, a sigh or deep and full inspiration will certainly soon follow.

The grounds which have been taken by professor Cocke, on the subject of respiration, and which appear to me to be plausible, are the following: 1st. That oxygen gas is absorbed by the venous blood and gives to arterial blood its vermilion colour. 2d. That the venous blood parts with water and carbonic acid gas by the lungs, and not with either carbon or hydrogen. 3d. That the water and carbonic acid gas are not formed in the lungs, but that the oxygen absorbed is gradually combining, chemically, with the carbon and hydrogen in the

course of the circulation, whence results the water and carbonic acid gas discharged. 4th. That animal heat is evolved in a direct proportion with the combination of the oxygen, and thus the heat for each part is given out from the blood, when the blood is in that part. 5th. That oxygen is the cause or supporter of the irritability of the system. That oxygen is absorbed by the venous blood and gives to it the arterial colour is abundantly shewn by many experiments. Girtanner exposed six ounces of venous blood to oxygen under a glass, it was immediately changed to a vermilion colour. The mercury in the glass arose six or eight lines, and the weight of the blood was slightly increased. In this case there was a change of colour and augmentation of weight which could be attributed to nothing, but the action and absorption of oxygen. The same author injected a quantity of pure oxygen gas into the jugular vein of a dog, which killed it in less than three minutes. The blood in the right auricle and ventricle was found of a bright vermilion colour; in this case, the change of colour could have been caused by nothing but the oxygen. Again, arterial blood was exposed to azot, it coagulated and became of a very deep, dark colour; on the next day a portion of oxygen was found in the azot, which supported the flame of a candle for two minutes—this oxygen must have been derived from the arterial blood. More than two thirds of the oxygen taken in at each inspiration disappears—that this is absorbed by the blood may be inferred from the blood having the same change effected in its colour that we find to take place when venous blood out of the body is exposed to an atmosphere of oxygen of which a part is known to be absorbed. That the vermilion colour of arterial blood is not produced by the seperation of carbone and hydrogen is proven by the well known fact, that venous blood discharged into a vial full of oxygen gas becomes instantaneously red without giving any appearance of carbon or hydrogen. That the venous blood parts with carbonic acid and water ready formed may be inferred from the consideration or fact, that the inevitable consequence of the union of oxygen with either carbon or hydrogen is the evolution of a considerable quantity of heat—that this does not take place, we conclude from the temperature of the blood in the left auricle being rather lower than that found in the right. If carbon and hydrogen were eliminated from the blood to be combined with the oxygen inhaled, in those cases where persons have died in contaminated air for the want of oxygen, there would have been some appearance in the lungs of the excreted carbon and hydrogen, which no person has ever ascertained to be the case.

It thus appears that oxygen is absorbed or taken up by the blood, as it passes through the lungs, and that carbonic acid gas and water are emitted. It has been shewn that these products are not formed in the lungs; the combination of the oxygen with the carbon and hydrogen to form them must then take place elsewhere. That oxygen should be so mixed with the blood as to be carried through the pulmonary veins and into the heart, is a point which has been strongly doubted, but is it more extraordinary or incomprehensible that oxygen gas, in its entire and undecompound state, should be taken into the blood, than that oxygen gas or air should be thus loosely mixed with common water? and yet we know that to be the case.—Fish have no lungs but are furnished with gills which perform a function equivalent to that of the lungs, the gills of fish cannot decompose water and obtain the oxygen which enters into its composition. They die very soon on being plunged into distilled water, or into that which has recently been boiled—exposure of this water for some time to the air again qualifies it to accommodate fish. Hence we may conclude, that the water contains oxygen gas or atmospheric air in a state of mixture. That being admitted, it may be conceded that the oxygen is taken up in the same condition, and changes venous into arterial blood.

On the instant that the blood has received the oxygen, I conceive the process of chemical combination to commence between the oxygen and the carbon and hydrogen of the blood, and that this process goes on actively until the oxygen has combined with proportionable quantities of hydrogen and carbon, the water and carbonic acid thus formed are discharged not only on the arrival of the blood at the lungs, but also in the course of its circulation, by the skin, as has been shewn by Abernethy's experiments.

All modern philosophers admit that animal heat is very intimately connected with respiration, but much difference of opinion prevails as it regards the manner in which it is produced. Of some of these hypotheses I have already taken slight notice. That which is more satisfactory than any other that I have seen is the following:

The oxygen being received in its entire state and intimately mixed with the whole mass of blood, begins immediately to combine chemically, with the carbon and hydrogen which it meets with in the circulating mass, and in direct ratio with this combination is the quantity of heat evolved; the time which is required for the entire combination of the oxygen with these articles, may be about equal to that in which it passes through the arterial system, and thus each part receives heat in proportion to the quantity of blood that goes to it, and not ac-

cording to its distance from the heart or lungs. The absurdity itself of the idea of the blood being heated in the lungs, and then conveying the heat to other parts, should set that doctrine aside, even if it were not contradicted by the experiments of Messrs. Cooper and Coleman, and by Stevenson. In the experiments of the two former gentlemen, the blood in the right auricle was uniformly found to be one degree higher in temperature than that in the left auricle—but they found that after a short time, the thermometer in the right auricle fell one or two degrees below that at which the thermometer in the left auricle stood. Of which circumstances they offer the following very ingenious explanation. They allow that the temperature of the blood in the right auricle may be a little reduced by the recent exposure of the blood to the atmospheric air ; but also to another circumstance which will be noticed presently. The blood as it arrives at the left auricle and ventricle, is fully charged with oxygen and heat in a latent state, which was destined to be distributed over the aortic system, but in experiments being confined by ligature, it remains in the cavities of the heart where continuing to combine with the carbon and hydrogen, it gradually gives out its heat, thus supporting the mercury at the point at which it is first found to be, until the oxygen has ceased to combine farther : whereas the blood which passes in its course by the arteries and into the veins, has all its oxygen combined by the time that it gets back to the right auricle, and having been subjected to the action of the heat, which has passed from it in the course of the circulation, its sensible heat is in some measure augmented thereby, which circumstance in addition to the reduction of the temperature by contact of air, is supposed to account for the degree of caloric found in the blood of the right over that in the left auricle.

According to this beautiful and simple theory, we have not only a regular and adequate supply of heat furnished to every part of the body, but a method pointed out by which the redundant or useless carbon and hydrogen may be uniformly thrown off from the system.

Many experiments have been made which shew that oxygen maintains and increases the irritability of the system—as, however, this thesis is already much extended beyond the limits contemplated, I shall rest on a few of them.

In the experiment of Girtanner already mentioned, in which he injected oxygen into the veins of a dog, he found the heart much more irritable than usual. I shall close this subject by quoting the result of the 20th experiment published in the ingenious inaugural essay of Dr. Oswald.

"Having procured," says the Doctor, "several kittens of the same litter, and nearly equal in size, my friend, Mr. Nelson holding a stop watch, I exposed two of them to the action of oxygen gas (contained under a glass vessel inverted over the pneumatic tub,) obtained from the black oxyd of Manganese by heat, for the space of ten minutes, after which, they were both plunged under water, and struggled for six minutes when they became feeble, and were taken out apparently dead in seven minutes and fifty seconds. The third was treated in the same manner, with similar results, varying only in degree: on dissection, the heart was still contracting and retained its irritability for a very considerable time, in two instances for the space of five hours.

"The 4th and 5th were plunged under water of the same temperature, in a natural state, and were taken out apparently dead, in three minutes and ten seconds, but on dissection the heart was still contracting, though feebly, and ceased altogether in a few minutes." (Page 45.)

Before I conclude this dissertation, permit me, gentlemen, to express the deep sense of obligation I am under for the uniform and polite attention I have received from you individually, as gentlemen, and the manifold advantages I have derived from you collectively, as teachers. I exult in the idea that the school in which you teach, to the great edification of your pupils, will be the means of making known the true philosophy of physic; a shool, where science is enthroned to the exclusion of visionary follies, random opinions, and undigested doctrines; and where disease, instead of being considered a series of undistinguishable grades, is systematized into order, and brought within the sphere of successful treatment, by the plain rules of correct and rational pathology.

THE END.

Book taken apart. Leaves deacidified with magnesium bicarbonate. All leaves supported with lens tissue. Resewed on linen cords. New all-rag end paper signatures. Unbleached linen hinges. Rebound in quarter unbleached linen. Fabriano paper sides.

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